CMSC201
Computer Science I for Majors
Lecture 07 – Strings and Lists

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Last Class We Covered

• One-way, two-way, and multi-way decision structures
  – *if*, *if-else*, and *if-elif-else* statements
• Control structures (review)
• Conditional operators (review)
• Boolean data type (review)
• Coding algorithms using decision structures
Any Questions from Last Time?
Today’s Objectives

• To discuss the usage of `eval()` and the potential security concerns
• To learn about lists and what they are used for
• To better understand the string data type
  – Learn how they are represented
  – Learn about and use some of their built-in functions
• To be able to apply string formatting to produce attractive, informative program output
About `eval()`
Previous Uses of `eval()`

- Remember our temperature converter?

```python
def main():
    celsius = eval(input("What is the Celsius temperature? "))
    fahrenheit = 9/5 * celsius + 32

    print("The temperature is ", fahrenheit,
        " degrees Fahrenheit.")

main()
```

What does `eval` do?
The Problem with \texttt{eval()} \\

- \texttt{eval()} interprets a string as code \\
- It lets a Python program run Python code within itself \\
- In our example, we use it to let Python decide what data type to store the input as  
  - If the user gives us an integer, store it as an int  
  - If the user gives us a decimal, store it as a float  \\
- Using \texttt{eval()} is a security hole.
The Problem with `eval()`

• **But** if the user gives us a malicious command to delete files or folders, it may also run that

• If you have `os` imported, and you ask for input using `eval(input())`, someone could type malicious code like in response
  – `os.system('rm hw1.py')`
  – This would delete your `hw1.py` file!
What to Do Instead?

• Instead of using `eval()` to cast strings...

• Use the exact type you want to cast to:
  – `int(input())`
  – `float(input())`

Fixing the Temperature Converter

```python
def main():
    celsius = float(input("What is the Celsius temperature? "))
    fahrenheit = 9/5 * celsius + 32

    print("The temperature is ", fahrenheit, " degrees Fahrenheit.")

main()
```

Changed to a float cast
Introduction to Lists
Exercise: Average Three Numbers

• Read in three numbers and average them
  
  ```python
  num1 = int(input("Please enter a number: "))
  num2 = int(input("Please enter a number: 
  num3 = int(input("Please enter a number: 
  print((num1 + num2 + num3) / 3)
  ```

• Easy! But what if we want to do 100 numbers? Or 1000 numbers?

• Do we want to make 100 or 1000 variables?
Using Lists

• Need an easy way to hold onto individual data items without needing to make lots of variables
  – Making `num1, num2, ..., num99, num100` is time-consuming and impractical

• Instead, we can use a list to hold our data
  – A list is a data structure: something that holds multiple pieces of data in one structure
Using Lists: Individual Variables

- We need an easy way to refer to each individual variable in our list
  - Math uses subscripts ($x_1, x_2, x_3$, etc.)
  - Instructions use numbers ("Step 1: Combine..."")

- Programming languages use a different syntax
  - `x[1], x[0], instructions[1], point[i]`
Numbering in Lists

• Lists don’t start counting from 1
  – They start counting from 0!

• Lists with n elements are numbered from 0 to n-1
  – The list below has 5 elements, and is numbered from 0 to 4

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>
Properties of a List

- Heterogeneous (any data type!)
- Contiguous (all together in memory)
- Ordered (numbered from 0 to n-1)
- Have random (instant) access to any element
- Add elements using the append method
- They’re “mutable sequences of arbitrary objects”
List Syntax

• Use [] to assign initial values (*initialization*)

```python
myList = [1, 3, 5]
words = ["Hello", "to", "you"]
```

• And to refer to individual elements of a list

```python
>>> print(words[0])
Hello
>>> myList[0] = 2
```
List Example: Grocery List

• You are getting ready to head to the grocery store to get some much needed food

• In order to organize your trip and to reduce the number of impulse buys, you decide to make a grocery list
List Example: Grocery List

• Inputs:
  – 3 items for grocery list

• Process:
  – Store grocery list using list data structure

• Output:
  – Grocery list
def main():
    print("Welcome to the Grocery Manager 1.0")
    // initialize the value and the size of our list
    grocery_list = [None]*3

    grocery_list[0] = input("Please enter your first item: ")
    grocery_list[1] = input("Please enter your second item: ")
    grocery_list[2] = input("Please enter your third item: ")
    print(grocery_list[0])
    print(grocery_list[1])
    print(grocery_list[2])

main()
Grocery List Demonstration

• Here’s a demonstration of what the code is doing

bash-4.1$ python groceries.py
Please enter your first item: milk
Please enter your second item: eggs
Please enter your third item: oil

milk
eggs
oil

grocery_list[0] = input("Please enter ...: ")
grocery_list[1] = input("Please enter ...: ")
grocery_list[2] = input("Please enter ...: ")
print(grocery_list[0])
print(grocery_list[1])
print(grocery_list[2])
List Example: Grocery List

• What would make this process easier?

• Loops!
  – Instead of asking for each item individually, we could keep adding items to the list until we wanted to stop (or the list was “full”)

• We will learn more about loops in the next couple of classes
Strings
The String Data Type

• Text is represented in programs by the string data type

• A string is a sequence of characters enclosed within quotation marks (" ) or apostrophes ( ’ )
  – Sometimes called double quotes or single quotes

• FUN FACT! – The most common use of personal computers is word processing
String Examples

```python
>>> str1 = "Hello"
>>> str2 = 'spam'
>>> print(str1, str2)
Hello spam
>>> type(str1)
<class 'str'>
>>> type(str2)
<class 'str'>
```
Getting Strings as Input

• Using `input()` automatically gets a string

```python
>>> firstName = input("Please enter your name: ")
Please enter your name: Shakira
>>> print("Hello", firstName)
Hello Shakira
>>> type(firstName)
<class 'str'>
>>> print(firstName, firstName)
Shakira Shakira
```
Accessing Individual Characters

• We can access the individual characters in a string through *indexing*

• The characters in a string are numbered starting from the left, beginning with 0
  — Does that remind you of anything?
Syntax of Accessing Characters

• The general form is

```
STRING[EXPR]
```

• Where `STRING` is the name of the string variable and `EXPR` determines which character is selected from the string.
Example String

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>e</td>
<td>l</td>
<td>l</td>
<td>o</td>
<td>B</td>
<td>o</td>
<td>b</td>
<td></td>
</tr>
</tbody>
</table>

```python
>>> greet = "Hello Bob"
>>> greet[0]
'H'
>>> print(greet[0], greet[2], greet[4])
H l o
>>> x = 8
>>> print(greet[x - 2])
B```
Example String

0 1 2 3 4 5 6 7 8
Hello Bob

• In a string of $n$ characters, the last character is at position $n-1$ since we start counting with 0

• Index from the right side using negative indexes

>>> greet[-1]
'b'

>>> greet[-3]
'B'
Substrings and Slicing
Substrings

• Indexing only returns a single character from the entire string

• We can access a *substring* using a process called *slicing*
  – Substring: a (sub)part of another string
  – Slicing: we are slicing off a portion of the string
Slicing Syntax

- The general form is

  \texttt{STRING [START : END]}

- \texttt{START} and \texttt{END} must both be integers
  - The substring begins at index \texttt{START}
  - The substring ends \underline{before} index \texttt{END}

  - The letter at index \texttt{END} is not included
Slicing Examples

0 1 2 3 4 5 6 7 8
Hello Bob

>>> greet[0:3]
'Hel'

>>> greet[5:9]
'Bob'

>>> greet[0:5]
'Hello'

>>> greet[1:]
'ello Bob'

>>> greet[::]
'Hello Bob'
Specifics of Slicing

• If **START** or **END** are missing, then the start or the end of the string are used instead

• The index of **END** must come **after** the index of **START**
  – What would the substring `greet[1:1]` be?
    ```
    ,
    ```
  – An empty string!
More Slicing Examples

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>e</td>
<td>l</td>
<td>l</td>
<td>o</td>
<td>B</td>
<td>o</td>
<td>b</td>
<td></td>
</tr>
</tbody>
</table>

-9 -8 -7 -6 -5 -4 -3 -2 -1

```
>>> greet[2:-3]
'llo '

>>> greet[-6:-2]
'lo B'

>>> greet[-6:6]
'lo '

>>> greet[-9:8]
'Hello Bo'
```
Forming New Strings - Concatenation

• We can put two or more strings together to form a longer string

• Concatenation “glues” two strings together

    >>> "Peanut Butter" + "Jelly"
    'Peanut ButterJelly'

    >>> "Peanut Butter" + " & " + "Jelly"
    'Peanut Butter & Jelly'
Forming New Strings - Repetition

• Concatenating the same string together multiple times can be done with repetition
  – Which operator would you use for this?

```python
>>> animal = "dogs"
>>> animal*3
'dogsdogsdogs'
>>> animal*8
'dogsdogsdogsdogsdogsdogsdogsdogs'
```
Practice: Spam and Eggs

```python
>>> "spam" + "eggs"
'spameggs'

>>> "Spam" + "And" + "Eggs"
'SpamAndEggs'

>>> 3 * "spam"
'spamspamspam'

>>> "spam" * 5
'spamspamspamspamspam'

>>> (3 * "spam") + ("eggs" * 5)
'spamspamspameggseggseggseggseggseggseggseggss'
Length of a String

• To get the length of a string, use `len()`

```python
>>> title = "CMSC 201"
>>> len(title)
8
>>> len("Help I'm trapped in here!")
24
```

• Why would we need the length of a string?
# String Operators in Python

<table>
<thead>
<tr>
<th>Operator</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Concatenation</td>
</tr>
<tr>
<td>*</td>
<td>Repetition</td>
</tr>
<tr>
<td>STRING[#]</td>
<td>Indexing</td>
</tr>
<tr>
<td>STRING[#:#]</td>
<td>Slicing</td>
</tr>
<tr>
<td>len(STRING)</td>
<td>Length</td>
</tr>
<tr>
<td>for VAR in STRING</td>
<td>Iteration</td>
</tr>
</tbody>
</table>

We’ll cover this next class, when we learn *for* loops!
Just a Bit More on Strings

- Python has many, many ways to interact with strings, and we will cover them in detail soon.
- For now, here are two very useful functions:
  - `s.lower()` — copy of `s` in all lowercase letters
  - `s.upper()` — copy of `s` in all uppercase letters
- Why would we need to use these?
  - Remember, Python is case-sensitive!
String Processing Examples
Example: Creating Usernames

- Our rules for creating a username:
  - First initial, first 7 characters of last name (lowercase)

```python
# get user’s first and last names
first = input("Please enter your first name: ")
last = input("Please enter your last name: ")

# concatenate first initial with 7 chars of last name
uname = first[0].lower() + last[:7].lower()
print("Your username is: ", uname)
```

Why is this 7?
Example: Creating Usernames

```python
>>> first = input("Please enter your first name: ")
Please enter your first name: Donna
>>> last = input("Please enter your last name: ")
Please enter your last name: Rostenkowski

>>> uname = first[0] + last[:7]
>>> print("Your username is: ", uname)
Your username is DRostenk

Usernames must be lowercase!

>>> uname = first[0].lower() + last[:7].lower()
>>> print("Your username is: ", uname)
Your username is drostenk
```
Example: Creating Usernames

```python
>>> first = input("Please enter your first name: ")
Please enter your first name: Barack
>>> last = input("Please enter your last name: ")
Please enter your last name: Obama

>>> uname = first[0].lower() + last[:7].lower()
>>> print("Your username is: ", uname)
Your username is bobama
```

- What would happen if we did `last[7]`?
  - `IndexError` — but why does `last[:7]` work?
Example: Printing the Months

• Given an integer (from 1 to 12) print the three letter abbreviation for that month

• Start by storing all the names in one big string:
  ```
  months = "JanFebMarAprMayJunJulAugSepOctNovDec"
  ```

• Use the number of the month to get the right “slice” of the `months` string
Example: Printing the Months

• Let’s figure out the position for each month name:

```python
months = "JanFebMarAprMayJunJulAugSepOctNovDec"
```

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Num</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Pos</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Month</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Num</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Pos</td>
<td>18</td>
<td>21</td>
<td>24</td>
<td>27</td>
<td>30</td>
<td>33</td>
</tr>
</tbody>
</table>
Example: Printing the Months

• Notice a pattern?

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Num</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Pos</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
</tbody>
</table>

• To get the position, subtract 1 from the month’s number and multiply by 3

\[ \text{pos} = (\text{num} - 1) \times 3 \]

• Use it to get the month name from the string
Example: Printing the Months

def main():
    months = "JanFebMarAprMayJunJulAugSepOctNovDec"

    n = int(input("Enter a month number (1-12): "))

    # compute starting position of month n in months
    pos = (n-1) * 3

    # grab the appropriate slice from months
    monthAbbrev = months[pos:pos+3]

    # print the result
    print ("The month abbreviation is", monthAbbrev)

main()
Example: Printing the Months

bash-4.1$ python months.py
Enter a month number (1-12): 1
The month abbreviation is Jan

bash-4.1$ python months.py
Enter a month number (1-12): 12
The month abbreviation is Dec

bash-4.1$ python months.py
Enter a month number (1-12): 100
The month abbreviation is

What happened?

months[297:300]

There’s nothing there in the string!
Announcements

• Your Lab 4 is meeting normally this week!
  – Make sure you attend your correct section

• Homework 3 is out
  – Due by Thursday (Sept 24th) at 8:59:59 PM

• Homeworks are on Blackboard
  – Weekly Agendas are also on Blackboard